COLLOCATION IMPACTS ON THE VULNERABILITY OF LIFELINES DURING EARTHQUAKES WITH APPLICATION TO THE CAJON PASS, CALIFORNIA

1.0 CONCLUSIONS

The purpose of this study was to:

develop a management screening tool that can be used by lifeline owners, designers and providers, operators, users, and regulators to sort through numerous collocation conditions to identify the critical locations and to provide an estimate of the increased risk that results when such collocated facilities are subjected to an earthquake event; and to

analyze the Cajon Pass, California, situation to demonstrate how the screening tool can be used and to examine specific conditions at the Pass.

The resulting screening tool is an important development for several reasons:

1) it is the first documented method for examining multiple collocation conditions and it is applicable to all lifeline facilities. As improvements are made in the fundamental analysis methods for individual lifelines or earthquake conditions, they readily can be introduced into the screening tool to improve its predictive ability;

2) its use can identify the most critical collocation conditions at a specific study area, thereby allowing limited resources to be focused on the most important conditions for improving the overall ability of the lifelines to survive an earthquake event;

3) its use can identify technical areas of uncertainty and/or poor siting practices. This can identify the need for and lead to further research and studies to reduce the identified technical uncertainty or it can identify ways to mitigate siting practices that are more vulnerable to inducing collocation failure conditions; and

4) by being documented and made widely available by the Federal Emergency Management Agency, it is anticipated that it will stimulate the earthquake and lifeline communities to developed improvements in the analysis method or even to develop new, improved screening methods.

The development of the analysis methodology as well as its test application to the Cajon Pass has highlighted several important conclusions.

- Lifeline collocation can produce both benefits and increased risk of failure during earthquake events. A benefit of closely located transportation lifelines is that the second lifeline can provide the detour or access route to the damaged sections of the first lifeline. However, intersecting lifelines generally result in the failure of one lifeline increasing the risk of failure of the lifeline(s) it crosses.

- It is understandable that topographic conditions have led to the routing of lifeline systems in corridors. However, manmade considerations that force the lifeline owners to use the same rights-of-way for widely different lifelines (for example, locating petroleum fuel pipeline and communication conduits next to each other, routing natural gas pipelines back and forth under a railroad bed, and having a mix of lifelines cross the earthquake fault zone at the same location) greatly increase the risk of failure for the individual lifelines and the complications that will be encountered during site restoration after an earthquake.

- As compared to buildings, ground movement is more important that ground shaking for lifeline components, especially buried lifelines and electrical transmission towers. This means that much of the technical data base on earthquake shaking intensity is not critical for lifeline analysis, whereas important ground movement data and analyses are not as well developed as the shaking intensity data. This suggests that future studies need to emphasize obtaining ground movement information.

- A very useful screening tool has been developed during this study. The tool can be used to identify the critical lifeline collocation locations and the conditions that make them critical. It can identify areas of technical uncertainty and poor siting practices, and its use can identify important research and development activities that can lead to lowered risk of collocation-induced lifeline failures. It will be of value to lifeline owners, designers and providers, operators, users, and regulators.

- The analysis tool has been successfully applied to the Cajon Pass, California. It has identified that for this semi-desert region that:

    The Cajon Junction, Lone Pine Canyon (which contains the San Andreas fault zone), Blue Cut, and the area just south of the interchange between I-15 and I-215 are the critical locations in terms of collocation impacts at the Cajon Pass.

    Fuel pipeline failures have the greatest impact on the other lifelines during the immediate recovery period after an earthquake.

Current siting practices for fiber optic cables indicates that more severe telephone communication failures than have been experienced in past earthquakes can be anticipated in future earthquakes when fiber optic systems have become more dominant in providing the basic telephone service.

Lifeline siting practices have not fully considered the impacts that a new lifeline will have on existing lifelines and, conversely, the impacts that the existing lifelines will have on the new lifeline.

Transportation lifeline restoration of service is highly dependent on sequentially repairing the lifeline damage as the lifeline itself is needed to provide access to the next damage location. Parallel repair operations are more probable for the other lifeline systems.

Communication, electric power, and fuel pipeline lifelines can generally be analyzed as a set of discrete collocation points. The restoration of service at any one point is not a strong function of the restoration work that is needed at other collocation points. Thus, if there is a restoration problem that will take a long time compared to the other locations, it becomes the "critical path" that sets the time period for the restoration of the entire lifeline system.

When multiple lifelines of the same class are collocated (such as installing all fiber optic cables or all fuel pipelines in the same or parallel trenches) or when multiple different lifelines intersect at a common point, the reliability of each individual lifeline decreases to the value of the "weakest link" of the combined lifeline systems. In addition, repair times increase because of local congestion and the concern that work on one lifeline component could lead to damage of the other different lifeline components.

- There is a need for further collocation lifeline studies: to apply the newly developed screening tool to other locations to assure that the methods can be transferred to other U.S. locations and to analyze different lifelines, geographic, and earthquake conditions; and to develop data and approaches that can be used to further improve the predictive capabilities of the screening tool.